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WASTE DISPOSAL AT A STEEL PLANT: TREATMENT OF FLUE DUST WASTE

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WASTE DISPOSAL AT A STEEL PLANT: TREATMENT OF FLUE DUST WASTE

Angus D. Henderson[1] and John J. Baffa,[2] A.M., ASCE

I. Introduction

The treatment of waters laden with flue dust from steel mill blast furnace operations is usually undertaken to recover high iron content dust and improve the quality of discharges to receiving streams. Ordinarily, both objectives are achieved in one primary thickening operation. The treatment facilities provided at the Fairless Works are unique in that the primary thickener effluent required further treatment in accordance with the announced policy of the United States Steel Corporation to maintain the water quality of the Delaware River. Accordingly, the primary flue dust thickener effluent is given secondary treatment before discharge to the Delaware River. Construction of these works was completed early in 1953 and operations have been under way since May, 1953.

II. Origin and Character of Wastes

Waters laden with flue dust result from the wet scrubbing of blast furnace gas. The action in the wet scrubbers generally comprises downflow water sprays which clean the upflowing gases of dust content. The wet scrubbing operation is usually an intermediate stage between dry cyclone dust separation and final electrostatic precipitation of remaining fines. Secondary gas washers or precipitators are periodically cleaned by water flushing, and at these times, add to the discolored water flow.

The wet gas washer effluent contains flue dust solids composed of iron oxide, alumina, silica, carbon, lime and magnesia. Proportions of the constituents and total quantity of dust varies with the type of ore used in the furnace, condition of furnace lining, quality of coke used, the number of furnaces in blast, amount of air being blown, the regularity and thoroughness of dumping and flushing of dry dust catchers. The greatest single constituent of the flue dust content of the gas washer effluent is iron oxide, comprising about 70% by weight (as Fe_2O_3) of total solids. Silica is present at about 12% by weight and percentages for other constituents are approximately equally divided.

All solids removed from flue gases can be said to be in suspension in the wet washer effluent and can be determined as suspended solids.

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The suspended solids concentration of wet washer effluents will generally vary between 1,000 and 4,500 parts per million with a mean of 2,000 ppm. Observations made at other mills indicate that concentrations of 2,500 ppm. are exceeded only about 18% of the time and values above 3,000 ppm are found 8% of the time.

Mechanical analysis of 9 consecutive samplings at another mill showed 86% to 99% by weight passing a #100 mesh sieve and 74% to 97% by weight passing the #200 mesh sieve. Accordingly, the effective size is in the hydrometer analysis range as would be expected for a dust.

The temperature of the washer effluent is generally 100° to 120°F. The pH varies considerably. It depends on the initial pH of the wash water as well as operating conditions and may range from 6 to 8 in the same plant. The specific gravity of the solids also fluctuates and has been found to vary from 3.0 to 3.8.

The above data on flue dust is representative of average conditions in the steel industry. At the Fairless Works, information on the wet washer flue dust content over a two months' period shows an average of 1,200 ppm. entering the primary thickener and a total ranage from 500 to 3,500 ppm.

III. General Description of Flue Dust Treatment

When planning the Fairless Works flue dust removal plant, a two stage process was decided upon; the first, providing primary sedimentation, and the second, giving flocculation and final clarification after the addition of lime. This results in corresponding color reduction, since the red appearance is due to the suspended iron oxides and there is little color in solution.

Of the total suspended matter present in the wet washer effluent, about 90% to 95% is readily settleable. About 98% of total settlement by volume occurs in one hour. Thus, with 95% removal of suspended solids by primary settling, the primary thickener effluent can be expected to contain between 50 and 200 ppm. concentration of suspended material.

Tests at five mills showed that primary thickener overflows were readily flocculated by lime alone. Laboratory scale flocculator tests indicated that the addition of lime in amount 0.1 to 0.3 pounds per 1,000 gallons (as CaO) with subsequent flocculation and settling, produced effluent containing less than 50 ppm. suspended solids with primary overflows ranging from 100 to 1,000 ppm. suspended matter.

Figure No. 1 shows a flow diagram of the wet wastes from blast furnace operations and treatment units provided. The wet washer wastes flow to the primary thickener. After settling, the primary overflow flows to the secondary treatment plant which comprises flash mixing, flocculation and final clarification. Facilities are provided for unloading, storing, slaking and feeding high calcium quicklime. Lime feed is proportioned according to flow through a measuring flume at the effluent end of the plant. Both primary thickener and secondary plant sludge are pumped to a storage lagoon.

IV. Volume of Wastes

The facilities shown in Figure No. 1 are designed to handle a maximum flow of 10,000 gallons per minute from the gas washers of the two plant furnaces. Hourly flow variations are expected depending upon blast furnace operations and flushing of dry dust catchers.

V. Treatment Units

The primary thickener is of reinforced concrete construction and is 90 feet in diameter with 12 feet side water depth providing one hour detention at design flow. Slurry is scraped to the center well and is pumped to a storage lagoon. The sludge generally has a 5% solids content by weight and is pumped continuously by rubber lined centrifugal pumps through a 4 inch diameter force main 800 feet long.

The photograph, Figure No. 2, shows the primary thickener which is located adjacent to the blast furnaces. The tank is covered with steel mesh netting to protect operations and prevent any falling objects from fouling equipment.

Figure Nos. 3 and 4 show plan and profile of the secondary treatment units.

The primary overflow flows through a 42 inch diameter pressure sewer by gravity to the secondary plant flash mixer.

The flash mixer tank has a capacity of 10,000 gallons providing one minute detention at design flow. A vertical high speed mixing unit is provided in this tank.

Conveyance of flows between flash mixer and flocculator and from clarifier to outfall is accomplished through reinforced concrete box conduits.

Flocculation tank is rectangular 28 feet by 74 feet in plan with 16 feet water depth providing 25 minutes detention at design flow. Vertical type flocculator units are provided.

The clarifier is 120 feet in diameter with 14 feet side water depth, providing two hours detention at design flow. This unit is provided with a mechanical sludge scraper.

Two sludge pumps are provided in the sludge pumping station. Pumps are positive displacement type sludge plunger pumps rated at 80 gpm. versus 60 feet total dynamic head. Sludge is pumped to the storage lagoon through a force main 6 inches in diameter and 1,300 feet long.

VI. Lime Handling and Feed

Figure No. 5 shows photograph of the lime handling and feed facilities. The lime unloading facilities, storage bin, slaking and feed facilities are all located in the single structure.

High calcium pebble lime one half inch size is delivered in box cars. Unloading is done by means of vacuum type equipment. The vacuum pump is located on the ground floor under the lime bin, and the receiver unit is located on top of the lime bin. The intermediate story directly below the lime bin houses the lime slaker and gravimetric lime feeder.

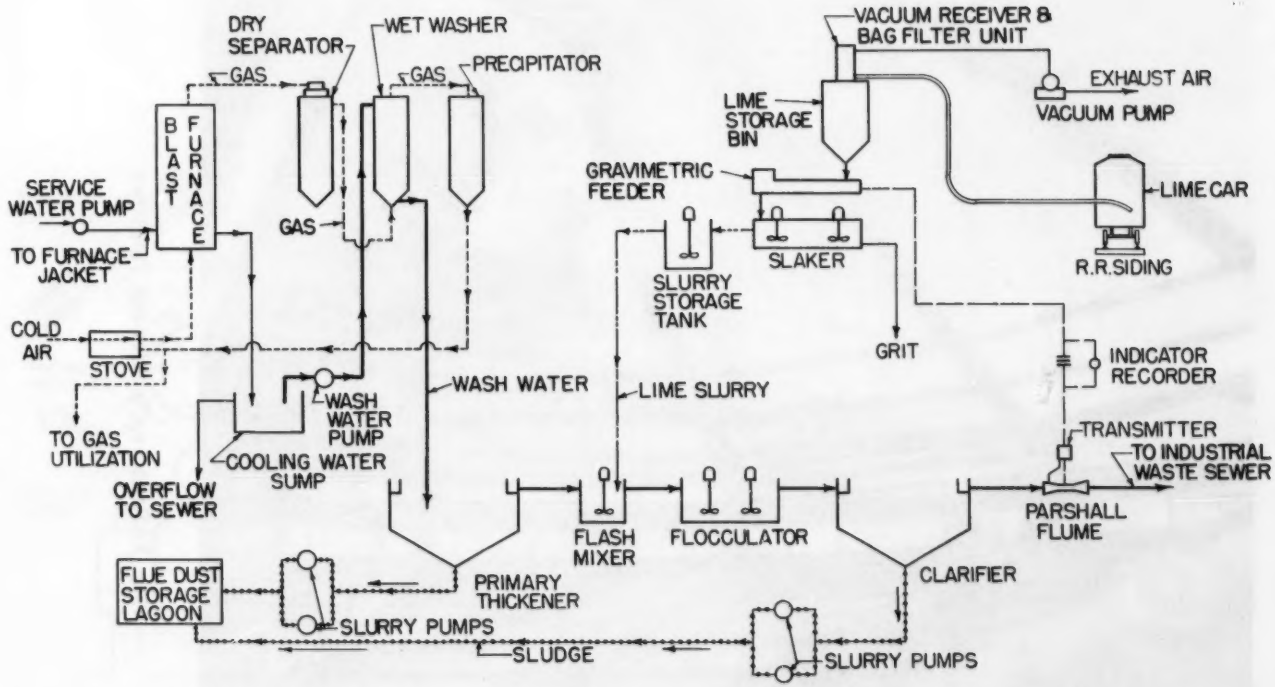
Lime feed is automatically proportioned according to flow through the effluent measuring flume. The agitated lime slurry storage tank is provided with 2,400 gallons capacity which represents 6 hours storage at average lime feed rate.

Lime storage bin capacity was chosen at seventy five tons or one and one half times one car load and provides a total of 50 days' storage.

VII. Results of Treatment

As the flue dust recovery and treatment plant has been in normal operation for a comparatively short period, it is too early to report statistically on the quality of the effluent discharged to the Delaware River.

Periodic analyses are being made of the effluent and the results of treatment are satisfactory and well within the limits set by the State regulatory body for pollution control.



FLOW DIAGRAM

FIGURE I

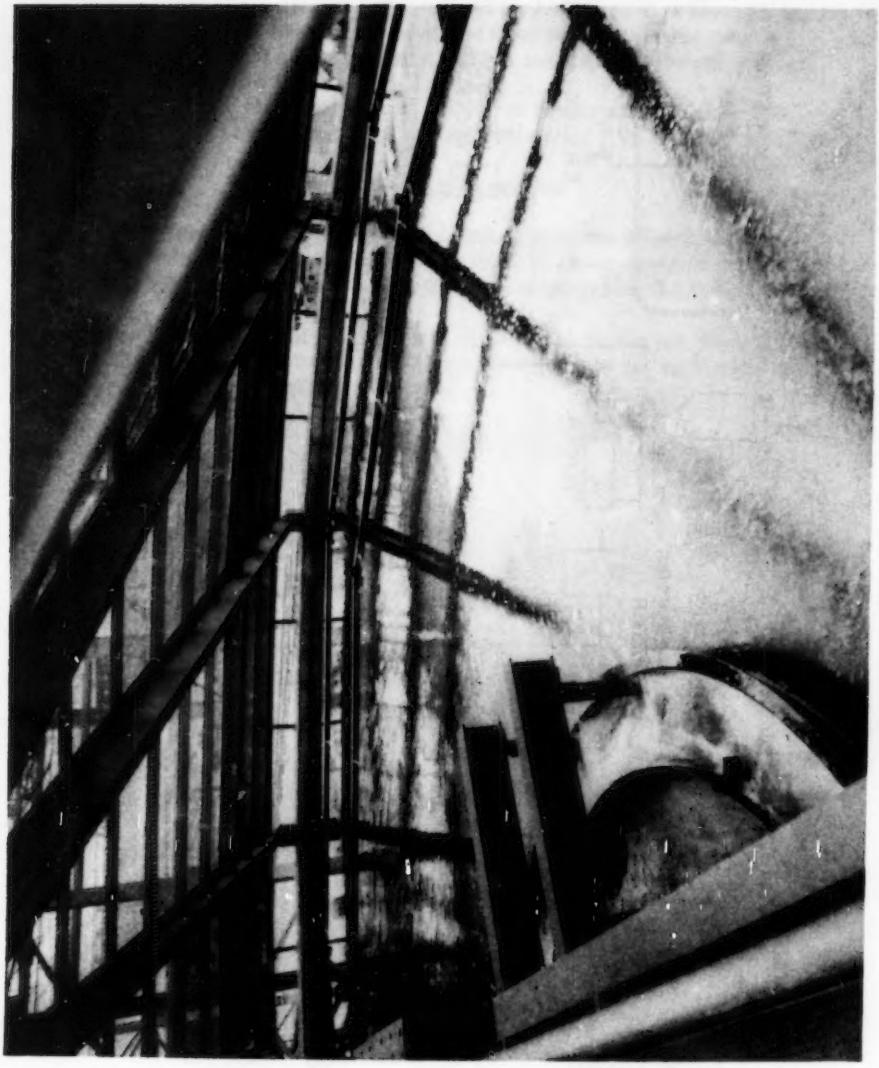
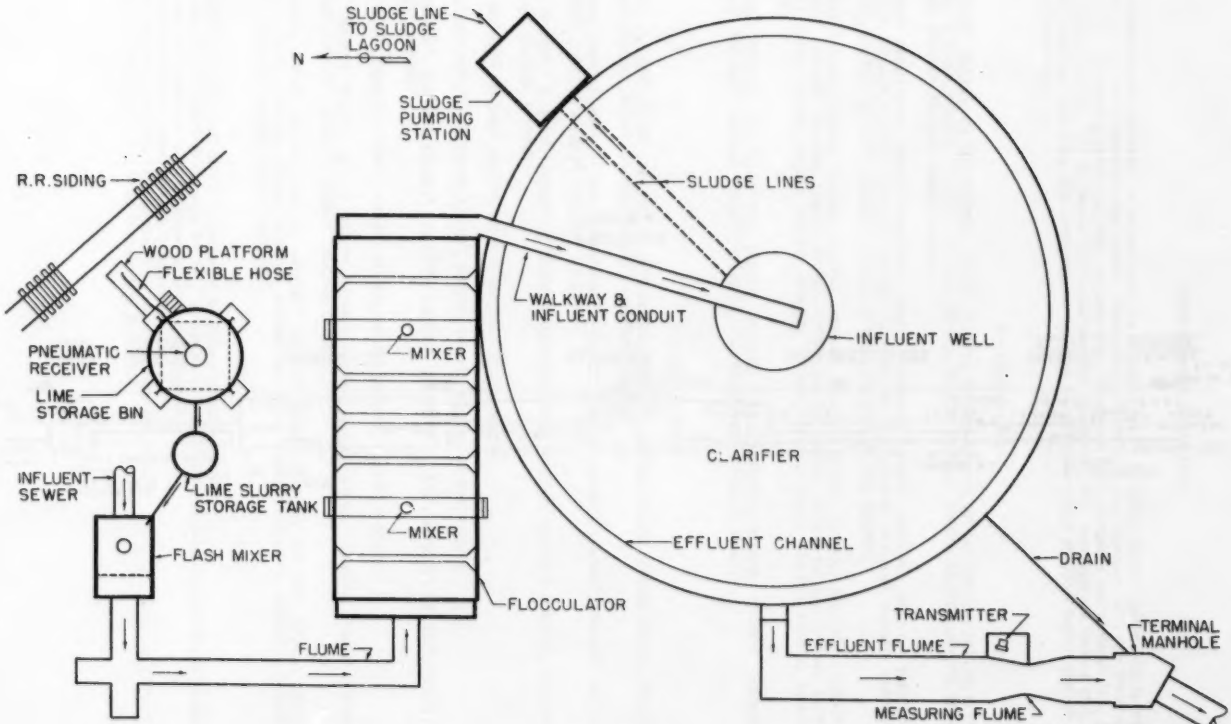
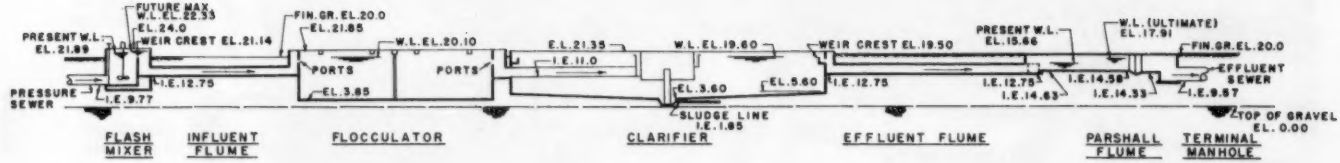


Fig. 2—Primary Clarifier and Thickener



SITE PLAN

FIGURE 3



PROFILE
FIGURE 4

PROCEEDINGS-SEPARATES

The technical papers published in the past year are presented below. Technical-division sponsorship is indicated by an abbreviation at the end of each Separate Number, the symbols referring to: Air Transport (AT), City Planning (CP), Construction (CO), Engineering Mechanics (EM), Highway (HW), Hydraulics (HY), Irrigation and Drainage (IR), Power (PO), Sanitary Engineering (SA), Soil Mechanics and Foundations (SM), Structural (ST), Surveying and Mapping (SU), and Waterways (WW) divisions. For titles and order coupons, refer to the appropriate issue of "Civil Engineering" or write for a cumulative price list.

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SEPTEMBER: 260(AT), 261(EM), 262(SM), 263(ST), 264(WW), 265(ST), 266(ST), 267(SA), 268(CO), 269(CO), 270(CO), 271(SU), 272(SA), 273(PO), 274(HY), 275(WW), 276(HW), 277(SU), 278(SU), 279(SA), 280(IR), 281(EM), 282(SU), 283(SA), 284(SU), 285(CP), 286(EM), 287(EM), 288(SA), 289(CO).

OCTOBER:[b] 290(all Divs), 291(ST)[a], 292(EM)[a], 293(ST)[a], 294(PO)[a], 295(HY)[a], 296(EM)[a], 297(HY)[a], 298(ST)[a], 299(EM)[a], 300(EM)[a], 301(SA)[a], 302(SA)[a], 303(SA)[a], 304(CO)[a], 305(SU)[a], 306(ST)[a], 307(SA)[a], 308(PO)[a], 309(SA)[a], 310(SA)[a], 311(SM)[a], 312(SA)[a], 313(ST)[a], 314(SA)[a], 315(SM)[a], 316(AT), 317(AT), 318(WW), 319(IR), 320(HW).

NOVEMBER: 321(ST), 322(ST), 323(SM), 324(SM), 325(SM), 326(SM), 327(SM), 328(SM), 329(HW), 330(EM)[a], 331(EM)[a], 332(EM)[a], 333(EM)[c], 334(EM), 335(SA), 336(SA), 337(SA), 338(SA), 339(SA), 340(SA), 341(SA), 342(CO), 343(ST), 344(ST), 345(ST), 346(IR), 347(IR), 348(CO), 349(ST), 350(HW), 351(HW), 352(SA), 353(SU), 354(HY), 355(PO), 356(CO), 357(HW), 358(HY).

DECEMBER: 359(AT), 360(SM), 361(HY), 362(HY), 363(SM), 364(HY), 365(HY), 366(HY), 367(SU)[c], 368(WW)[c], 369(IR), 370(AT)[c], 371(SM)[c], 372(CO)[c], 373(ST)[c], 374(EM)[c], 375(EM), 376(EM), 377(SA)[c], 378(PO)[c].

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JANUARY: 379(SM)[c], 380(HY), 381(HY), 382(HY), 383(HY), 384(HY)[c], 385(SM), 386(SM), 387(EM), 388(SA), 389(SU)[c], 390(HY), 391(IR)[c], 392(SA), 393(SU), 394(AT), 395(SA)[c], 396(EM)[c], 397(ST)[c].

FEBRUARY: 398(IR)[d], 399(SA)[d], 400(CO)[d], 401(SM)[c], 402(AT)[d], 403(AT)[d], 404(IR)[d], 405(PO)[d], 406(AT)[d], 407(SU)[d], 408(SU)[d], 409(WW)[d], 410(AT)[d], 411(SA)[d], 412(PO)[d], 413(HY)[d].

MARCH: 414(WW)[d], 415(SU)[d], 416(SM)[d], 417(SM)[d], 418(AT)[d], 419(SA)[d], 420(SA)[d], 421(AT)[d], 422(SA)[d], 423(CP)[d], 424(AT)[d], 425(SM)[d], 426(IR)[d], 427(WW)[d].

APRIL: 428(HY)[c], 429(EM)[c], 430(ST), 431(HY), 432(HY), 433(HY), 434(ST).

MAY: 435(SM), 436(CP)[c], 437(HY)[c], 438(HY), 439(HY), 440(ST), 441(ST), 442(SA), 443(SA).

JUNE: 444(SM)[e], 445(SM)[e], 446(ST)[e], 447(ST)[e], 448(ST)[e], 449(ST)[e], 450(ST)[e], 451(ST)[e], 452(SA)[e], 453(SA)[e], 454(SA)[e], 455(SA)[e], 456(SM)[e].

JULY: 457(AT), 458(AT), 459(AT)[c], 460(IR), 461(IR), 462(IR), 463(IR)[c], 464(PO), 465(PO)[c].

AUGUST: 466(HY), 467(HY), 468(ST), 469(ST), 470(ST), 471(SA), 472(SA), 473(SA), 474(SA), 475(SM), 476(SM), 477(SM), 478(SM)[c], 479(HY)[c], 480(ST)[c], 481(SA)[c], 482(HY), 483(HY).

SEPTEMBER: 484(ST), 485(ST), 486(ST), 487(CP)[c], 488(ST)[c], 489(HY), 490(HY), 491(HY)[c], 492(SA), 493(SA), 494(SA), 495(SA), 496(SA), 497(SA), 498(SA), 499(HW), 500(HW), 501(HW)[c], 502(WW), 503(WW), 504(WW)[c], 505(CO), 506(CO)[c], 507(CP), 508(CP), 509(CP), 510(CP), 511(CP).

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a. Presented at the New York (N.Y.) Convention of the Society in October, 1953.
b. Beginning with "Proceedings-Separate No. 290," published in October, 1953, an automatic distribution of papers was inaugurated, as outlined in "Civil Engineering," June, 1953, page 66.
c. Discussion of several papers, grouped by Divisions.
d. Presented at the Atlanta (Ga.) Convention of the Society in February, 1954.
e. Presented at the Atlantic City (N.J.) Convention in June, 1954.

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